dried enzymes and other proteins give results consistent with the behavior of the functioning enzyme.[4,5] An indication for a polaron conduction mechanism in the enzyme cytochrome oxidase has been obtained.[4]

Photochemical reactions in various biological systems (nerve, eye, photosynthesis) follow the Roginsky–Zeldovich) equation, which has long been known to describe charge-transport processes across inorganic semiconductor surfaces. A solid-state theoretical derivation of this equation applicable to reactions at both biological solid surfaces and inorganic surfaces has been developed.[2,3]

The concepts and theory of solid-state theory have also been applied to *ionic* processes in the living cell, because of evidence for crystallinity of cell water, and for complexing of conductive sodium and potassium ions by cell macromolecules.[6,7] Theoretically, therefore, one may treat ions dissolved in structured cell water like conduction-band electrons, and complexed ions like valence-band electrons in a semiconductor.[3]

The field of solid-state biology is wide open to the solid-state physicist, but it is extremely difficult because of purification problems and because of the essential role of water in living systems. Purification and analysis of state of purity of high-molecular-weight enzymes, such as cytochrome oxidase, is extremely difficult; one may reach a point beyond which purification destroys enzymatic activity and therefore destroys relevance of physical measurements to biological reality. To achieve biological relevance, semiconductive measurements on biological solids, such as proteins, should be made in a wet system. Unfortunately, protonic conduction in the water around the particles then interferes with measurements of electronic conduction within the particles. These experimental problems of solid-state biology are significantly more difficult than those already being faced by the organic solid-state physicists, as well summarized in a recent book.[8]

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Switch to microfiche?

I would like to add my support to the suggestion of Enrique Grünbaum and Claudio Gonzalez (October, page 13). I have recently bought a microfiche reader for my own use to avoid being swamped in a sea of reports within my specialty (reactor physics). Contemplating the volume of my bookcase space taken up by archival journals (I belong to several scientific societies), I would cheerfully prefer to have the future issues delivered in microfiche only. Aside from storage advantages, I have discovered that microfiche reading permits more convenient scanning, which is what, I am sure, most readers do with most articles. Of course, it is nice to have some articles to read and study in page form, but there are many, many of us with access to microfiche page-copying machines. All I would ask is approval to duplicate one copy without copyright worries.

As to price and availability of microfiche readers: My machine is a small, cheap French one which is quite adequate (about $50). It, and fancier European machines in the price range you mention, have been on the market for some years. The International Atomic Energy Agency has a system for information handling (International Nuclear Information System, INIS) which includes furnishing microfiche copies of reports, and this system is gaining acceptance in both advanced and developing countries; so there must be an acceptable number of user's machines in existence.

In brief, I don't think that study of the idea would take very long before a conclusion is reached that providing a microfiche alternative to journal subscribers is a good idea.

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Doctor of Arts degree

The present focus on PhD employment difficulties promises to obscure both the need for certain types of advanced-degree people and what is being done to provide the best postbaccalaureate education to satisfy those needs. I refer to the continuing demand for *well*

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prepared men and women to teach growing numbers of undergraduates, and to the development of graduate programs leading to the Doctor of Arts degree.

In *Science* (6 November, page 587) H. Guyford Stever, the president of Carnegie-Mellon University, has written briefly about DA programs in general as they already exist at CMU. Typically, the format is to reduce intense specialization in research and thereby obtain time both to study several disciplines and train in skills required to be successful undergraduate teachers. Such programs are well into planning stages at a number of universities, especially the ten funded this year by grants from the Carnegie Corporation.

Holders of DA degrees *will not* soon rush from commencement in swarms to fill unexpectedly great numbers of teaching positions. They *will* nevertheless be emerging to offer two- and four-year schools the results of their personal decisions to *teach* and their degree grantors' substantial efforts to help them implement those decisions. Of course their emergence will constitute competition for those PhD's who are forced to turn to teaching at a variety of levels. But can that fact be used to deny prospective college teachers the best preparation that universities can give them?

Successful DA programs will provide at least two-fold benefits. They will be an important contribution by higher education to society as a whole, and many gifted students will be able to build scholarly careers without a commitment to full-time research.

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Language exams disappear

Language requirements for the PhD degree in physics have been undergoing a rapid and substantial change in the two years since the report by Arnold Strassenburg and Margaret Llano (March 1969, page 45). At that time only three departments had no language requirements. By the Fall of 1969 the number having no language requirements had increased to 18 departments[1]. Our department did a survey in the Spring of 1970 that now indicates 36 departments no longer have language requirements. Among these schools are some of the most prestigious and most prolific including California Institute of Technology, Harvard, Illinois, Stanford and Wisconsin. A number of other important schools indicated a desire to move in this direction. I would expect that the influence of these schools will be felt in the near future.

Only about 13% of the schools still required the traditional two foreign languages. This number is down from 33% less than a year previously[1]. (I do not consider a computer language to be a "traditional" language.)

The consensus of the respondents seemed to be that languages are of cultural benefit but of little professional importance or usefulness. As the group at Dartmouth has pointed out, 95% of the important periodic physics literature appears in English. A number of schools allow satisfactory completion of undergraduate language courses to substitute for a formal language exam.

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Teaching in India

In June, 1967 (page 44), E. M. Hafner wrote about the failure of a Summer Science Institute he advised for physics teachers in India. These institutes are a still-expanding program, advised and partly financed by the National Science Foundation, to rejuvenate Indian science teaching. But according to the many letters Hafner's article inspired from others involved in the program, the problems Hafner described showed that the Summer Institutes had not only developed internal problems, but also were being trapped by some of the problems of Indian education they were designed to correct.

Last summer I visited several Summer Institutes for Bombay secondary-school teachers. I found that though the backwardness of the average Indian teacher has not changed, the Summer Institutes have. The subject matter, which in Hafner's institute was too western, has been Indianized. The style of teaching which was depressingly Indian, has been westernized. I will expand on this a bit.

The staff of each Summer Institute usually consists of five Indian faculty members of a sponsoring college plus an American advisor. This staff runs its own show, choosing style and subject matter. Hafner's Indian staff chose lecture material from the Feynman Lectures, which turned out to be over the heads of the student-teachers. The laboratories used not only experiments designed in the US but even American equipment. Now, the lecture material builds on what the student-teachers know and have to teach their own classes. The labs stress experiments with cheap, "nonscientific" materials; that is, the sort of experiments a teacher